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PROGRAMS DEVELOPED TO USE THE POLYCORDER DATALOGGER TO PERFORM TIME STUDIES OF THE EASI MINER COALING OPERATION

S. Neal, N.J. Stuart, J.K. Szymanski

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PROGRAMS DEVELOPED TO USE THE POLYCORDER DATALOGGER TO PERFORM TIME STUDIES OF THE EASI MINER COALING OPERATION

by

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ABSTRACT

To facilitate research in surface mining methods, it was necessary to follow-up previous time studies of the Easi Miner system in use at the Obed Mountain Coal Mine. This report details the development of a specialized time-study system using an electronic data-logger (the Polycorder) and a specially built keyboard that was used for an earlier study. As an improvement on earlier systems (where data was transferred directly to the VAX), it was decided that the data gathered with the Polycorder would be uploaded to an IBM PC compatible and saved on PC disks, to be transmitted to the Lab's VAX at a later date. Several hardware and software components were assembled to facilitate the transfer from Polycorder to PC and from PC to VAX.

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PROGRAMMES MIS AU POINT EN VUE D'UTILISER L'ENREGISTREUR POLYCORDER POUR EFFECTUER DES ÉTUDES DE TEMPS DU SYSTÈME D'EXPLOITATION DU CHARBON EASI MINER

par

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RÉSUMÉ

Dans le but de faciliter la recherche sur les méthodes d'exploitation minière à ciel ouvert, il était nécessaire de faire le suivi d'études de temps antérieures du système Easi Miner utilisé à la mine de charbon d'Obed Mountain. Le présent rapport explique en détail la mise au point d'un système spécialisé d'étude de temps au moyen d'un enregistreur de données électronique (le Polycorder) et d'un clavier spécialement conçu qui avait été utilisé lors d'une étude antérieure. Afin d'améliorer les systèmes précédents, selon lesquels les données étaient transférées directement au système VAX, il a été convenu que les données recueillies avec le Polycorder seraient chargées dans un ordinateur compatible IBM PC et mémorisées sur des disques PC, pour être transmises ultérieurement au VAX du laboratoire. Plusieurs composantes du matériel et du logiciel ont été rassemblées afin de faciliter le transfert du Polycorder au PC, et du PC au VAX.

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INTRODUCTION

The Operations research group of the CANMET Surface Mining Lab is currently engaged in time study research into various combinations of mining equipment. One site of particular interest is the Obed Mountain operation near Hinton, Alberta, where an unconventional method (the 'Easi Miner') is being used to mine coal and to load trucks. To facilitate the time studies, a datalogging device (the Omnidata 'Polycorder') was programmed to be used for monitoring. The events are registered on a custom keypad and the data stored in the datalogger's memory. At the end of a shift the data is down loaded into a personal computer and subsequently transfered to the Lab's VAX computer.

This report describes the programming and operation of the Polycorder for this purpose. This work is an extension of the polycorder application developed by Stuart and Guyn for monitoring dragline performance.

HARDWARE

The Keyboard

The keyboard used was a unit that was constructed for the dragline performance study, and consisted of 32 switches and a network of diodes. It plugs into the sensor input of the Polycorder and uses 9 digital lines. When no keys are pressed, all the digital channels are in the "ON" state. Whenever a key is pressed, channel 9 goes to the "OFF" state, and the other inputs assume a pattern that is unique for each key on the keyboard.

Functions Monitored

The program was used to monitor the activities of several vehicles: the Easi Miner itself, and up to eight trucks. At any given time, a truck might be being loaded by the Easi Miner, getting in position to be loaded (spotting), taking its load to the stockpile, or waiting to be loaded. At any given time, the Easi Miner might be digging, turning around, or idle. In addition to these activities, it was wished to record the times at which the Easi Miner passed any of ten markers.

Data Entry

Using the keyboard is quite straightforward. To record a truck activity, the particular truck is selected using the TR keys along the bottom row, and then the type of activity is entered using the SPOT, QUE., DUMP, or LOAD key. The truck number (0-7) and activity are displayed on the Polycorder display, and, if correct, recorded by pressing the ENTER key. If a keying error was made, the erroneous information can be erased with the CLR key and re-entered correctly. The same is true for all other input; if incorrect information has been entered, but the ENTER key has not been pressed, the error can be erased with the CLR key.

The procedure for recording the Easi Miner's activities is similar. As the machine begins cutting, moving, or idling, the time is recorded using the DIG., MOV., or IDLE keys, respectively. As with all entries, the information is not recorded until the ENTER key is pressed. If the miner passes a marker, that can be recorded by pressing one of the ST (Stake) keys, which are numbered 0-9, followed by the ENTER key.

If the user realizes, at any point, that the entry just made was incorrect, that fact can be noted using the ENTRY ERROR key, which inserts a note in the data file to indicate that the entry preceding it is invalid.

It is important to note that the time recorded in the datafile is the time at which the ENTER key is pressed.

Layout of Buttons

The keyboard is laid out as shown:

0	1	2	3	4	5	6	7
8	9	10	11	12	13	14	15
16	17	18	19	20	21	22	23
24	25	26	27	28	29	30	31

ENTER		CLR		SPOT	LOAD	DMP	QUE
ST 0	ST 1	ST 2	ST 3	ST 4	ST 5	ST 6	ST 7
ST 8	ST 9		DIG.	IDLE	MOV.		ENTRY ERROR
TR 0	TR 1	TR 2	TR 3	TR 4	TR 5	TR 6	TR 7

SOFTWARE

The Polycode Program

For ease of modification and debugging, the monitoring program was divided into seven different routines, each with a different function. The routines are START, MAIN, KEYS, ERROR, STAKE, TRUCK, and MINER. These are each described seperately below.

START: This routine opens the appropriate datafile, and sets up various markers so that the program will begin information recording immediately following any previously entered data. This prevents any accidental erasure of information, and ensures that a minimum amount of storage will be wasted.

KEYS: This routine monitors the state of the keyboard. The routine waits until a key is pressed, and gets a value from the digital input. This value is subtracted from 255 to form a "key number" from 0 to 31, and the key number is stored in memory. It then passes back control to the routine that called it.

ERROR: When called, this routine causes the Polycorder to emit a distinctive noise to indicate to the user that he or she has pressed an inappropriate key, then returns control to the routine that called it.

MAIN: This is the primary loop of the program.

(1) When called, it sets up the screen, and displays the amount of memory available and a "WAITING" prompt.

(2) It then calls the subroutine KEYS. When a key is pressed, control is passed back to MAIN, which recalls the key number from memory. The key number is checked to see if it is a valid key; if it is not, subroutine ERROR is called, and execution goes back to the beginning of (2).

(3) The program checks which row the pressed key is in. If it is in row 2 (counting from the top),

subroutine STAKE is called. If it is in row 4, TRUCK is called. If the key is in row 3, the program determines if it is either of the ST keys in that row. If it is a ST key, control is passed to STAKE. Otherwise, the routine MINER is called.

(4) After the various subroutines have been performed, MAIN waits for another keypress by calling KEYS. If anything other than ENTER or CLR is pressed, ERROR is called, and the program goes back to waiting for CLR or ENTER. If the key pressed is "CLR", the program clears the display and returns to (1) above. If the key is "ENTER", the vehicle, event, and time are recorded in the data file, and the program begins another cycle.

TRUCK: TRUCK is called if one of the TR keys (0-9) is pressed. The truck number is stored and displayed on the screen, and the routine waits for one of the four event keys (SPOT, DUMP, QUE., or LOAD) to be pressed. When one of those keys is pressed, the name of the event is also displayed in the screen, and control passes back to the main program.

STAKE: STAKE is run when the Easi Miner passes a marker on the field. It notes and displays the stake number, stores this information, and passes control back to MAIN.

MINER: The MINER subroutine handles both miner events, and the use of the ENTRY ERROR key. If the key pressed was a miner event (IDLE, DIG., or MOVE), this information is stored and shown on the screen. If the key was "ENTRY ERROR", a special code number is stored, and the message "ENTRY ERROR" appears on the Polycorder display.

The program listings and flowcharts are in Appendix A.

The Data File

The Polycorder stores information in named files, which are similar in nature to the files used by larger computers. The files are organized as pages of lines, with each line consisting of a specified number

of columns of numerical and alphanumerical data. The number of columns and type of information held in each column are set in a format file, which also contains the headings for each column and the number of lines per page.

What is Stored

Each line in the file used for this study describes one "event", the vehicle involved, and the time at which the event occurred. The vehicle and event numbers are as follows:

Vehicle Number	Type of Vehicle	Event Number	Type of Event
0 - 7	Truck	0 - 9	Marker
8	Easi Miner	10	Spotting
9	Entry Error	11	Loading
		12	Dumping
		13	Queueing
		14	Digging
		15	Idling
		16	Moving
		17	Entry Error

For recording purposes, these two numbers were combined into a single vehicle/event number. This was simply done by multiplying the event number by ten and adding the result to the vehicle number. Thus, if truck 6 was seen queuing, the event/vehicle number would be 13 X 10 + 6 = 136.

The Format

Each line of data in the file is in the following format:

VEHICLE/EVENT NUMBER | HOUR AND MINUTE | SECOND AND HUNDREDTH OF SECOND

The hour and minute are recorded as four digits in the form HHMM, and the seconds and hundredths are also stored as four digits in the format SSHH. The vehicle/event number is stored as a three digit number. Each line of data occupies 6 bytes, 2 bytes for each column.

DATA TRANSFER

Communications

The transfer of data to the VAX is accomplished in two steps. First, the information is uploaded from the Polycorder to an IBM PC or compatible, and stored on diskette. At a later time, the data is uploaded from the PC to the VAX for processing and analysis. Both file transfers are accomplished using Crosstalk, a telecommunications program sold by Microstuf, Inc.

Cable for PC

The PC and the Polycorder are connected using a 3-conductor cable with female RS232 connectors at each end. The PC end plugs into the serial port on the back of the PC; the other end is attached to the serial I/O port on the Polycorder. Electrically, the cable is a simple null modem, with the TD line on each RS232 plug connected to the RD line on the other.

Communications Set-up

Using mode 5-2 on the Polycorder, the following protocols are set:

BAUD: 1200 PARITY: N DUPLEX: F XMT PMTS: Y (yes) LINE REQ: <CR>
REPEAT REQ: B CONTINUOUS REQ: V STOP REQ: D INP LINE TERM: <CR>
INP MAX LENGTH: 80 TRANSMIT DELAY: 2 CHECKSUM: N
END OF LINE SEQ: <CR><LF> END OF PAGE SEQ: <CR>
END OF FILE SEQ: <CR><LF> MATING CALL: <CR>

A full explanation of these codes can be found in the Polycorder manual. A carriage return character can be entered into the protocols by typing (on the Polycorder keyboard) (CTR) 013; a line feed is entered with the sequence (CTR) 010. (CTR) refers to the key on the Polycorder marked CTR.

Crosstalk is a general-purpose telecommunications program, and its use is detailed in the manual that comes with it. The steps for using it with the Polycorder are detailed below.

(1) Connect the Polycorder to the PC using the cable.
(2) With the PC switched off, put the Crosstalk disk into drive A. Turn the PC on, and the system will load Crosstalk automatically. After a few moments, the "greeting" will

appear, followed by the command screen. The program prompts the user to select one of two command files called POLY1 and POLY2; the file selected depends on which IBM communications port the Polycorder is connected to. For COM1, use POLY1; for COM2, use POLY2. If the port number is unknown, load POLY1. If that fails to work, type:

<ESC> (the ESC key on the IBM keyboard)
LO <CR> (the letters LO followed by the RETURN key)

When prompted for which command file to use, select POLY2.

The program will go into terminal mode, and the message "LOCAL LINK ESTABLISHED" will appear at the bottom of the screen. To determine if the correct file has been chosen, put the Polycorder in terminal mode (7-3) and hit a few keys on the Polycorder keyboard. If nothing appears on the PC screen, load the other file as outlined above. Again, type a few characters on the Polycorder keyboard. If nothing appears on the PC screen, check to see if the cables are connected securely. If that is not the problem, consult the Crosstalk and Polycorder manuals.

If everything is working, type a few characters on the PC keyboard. If these appear on the screen of the Polycorder, the system is ready for use.

Details of the Crosstalk files can be found in Appendix B.

Exchanging Programs

Once connection between the PC and the Polycorder has been established, programs and data can be transferred using mode 2 of the Polycorder. For sending data, select the appropriate option from the Polycorder menu, and scroll through the file names (using the arrow-up and arrow-down keys) until the correct file name is found. Pressing ENTER on the Polycorder keyboard will put the Polycorder into a ready-to-transmit mode. Transmission of the data is begun by typing "V" on either the Polycorder or PC keyboard; if the PC is used, note that the "V" must be in upper case. The procedure for uploading Polycorder programs to the PC is identical; the only difference is the choice of "PGM" rather than "DAT" at the "XMIT SERIAL" prompt.

Uploading Data to the VAX

Crosstalk can also used to upload data to the Lab's VAX computer. The program is loaded as described above, and the Crosstalk file "STD" is chosen instead of the POLY file. When connection has been made to the VAX and the user has logged on, send the EDIT command to the VAX, and enter the desired filename for the Easi Miner data. Issue the "I" command to the VAX editor, and then the following to set up Crosstalk to transmit the file:

<ESC> PR CH 13
<ESC> SE

Crosstalk will then prompt for the name of a file to send. When this is entered, it will transmit the file to the VAX. When the transfer is complete, type ^Z (hold down the key marked CONTROL or CTRL, and simultaneously press the Z key) on the PC keyboard, followed by EXIT and a carriage return. This cause the VAX to save the specified file.

CONCLUSION

Processing the data can be thought of as having two components:

(1) An initial conversion of the data file into readable form and the presentation of the data as histograms. This stage involves little or no interpretation but yields useful data on the site-specific performance of the equipment studied.

(2) Statistical analysis - fitting distributions to the data obtained so that it can be used in non-site-specific models. This part of the analysis involves a degree of subjective interpretation.

Eventually a stochastic model of truck - Easi Miner interaction will be created using the SLAM II simulation language system. This will be a general-purpose tool applicable anywhere that Easi Miner use is contemplated.

This will be the subject of further reports.

PROPRIETARY INFORMATION

CROSSTALK and CROSSTALK XVI are trademarks of Microstuf, Inc.

POLYCORDER is a trademark of Omnidata International, Inc.

For more information about Crosstalk, contact:

Microrostuf, Inc.
1000 Holcomb Woods Parkway
Suite 440
Roswell, GA
30076
USA
(404) 998 7798

For more information about the Polycorder, contact:

Omnidata International, Inc.
P.O. Box 3489
Logan, Utah
84321
USA
(801) 753 7760

REFERENCES

1. N.J. Stuart and P. Guyn "A System for Gathering Dragline Data Using an Electronic Data Logger and Modem", Division Report ERP/CRL 84-44(TR); CANMET, Energy, Mines, and Resources Canada; 1984.

2. V. Srajer and N.J Stuart "The Study of Dragline Operation at Highvale Mine in Alberta", Division Report ERP/CRL 85-94(TR); CANMET, Energy, Mines and Resources Canada; 1985.

3. Microstuf Inc. "Crosstalk-XVI User's Manual"; 1984

4. Omnidata International, Inc. "User's Manual: Polycorder 516-B, Version 5.0"; 1983

APPENDIX A

PROGRAMS AND FLOWCHARTS

```
MAIN
  1. 13 DCM  0
  2. 22 SNG  50,20
  3. 12 WID  16
  4. 20 CDS  0,16
  5. 65 MEM
  6. 37 VUA
  7. 29 VUM  WAITING
  8. 32 GSB  KEYS
  9. 26 CON  24
 10. 96 AND
 11.  3 JNZ  14
 12. 32 GSB  ERROR
 13.  1 JMP  8
 14. 22 SNG  50,10
 15. 20 CDS  0,16
 16. 26 CON  16
 17. 96 AND
 18.  3 JNZ  21
 19. 32 GSB  STAKE
 20.  1 JMP  35
 21. 15 RCL  3
 22. 26 CON  8
 23. 96 AND
 24.  3 JNZ  33
 25. 15 RCL  3
 26. 26 CON  6
 27. 96 AND
 28.  3 JNZ  31
 29. 32 GSB  STAKE
 30.  1 JMP  35
 31. 32 GSB  MINER
 32.  1 JMP  35
 33. 32 GSB  TRUCK
 34.  5 JLZ  3
 35. 32 GSB  KEYS
 36.  2 JPZ  42
 37. 26 CON  2
 38. 80 SUB
 39.  2 JPZ  3
 40. 32 GSB  ERROR
 41.  1 JMP  35
 42. 22 SNG  50,10
 43. 15 RCL  1
 44. 26 CON  10
 45. 81 MLT
 46. 15 RCL  0
 47. 79 ADD
 48. 77 STF
 49. 61 ICP
 50. 61 ICP
 51. 66 TIM
 52. 77 STF
 53. 62 DCP
 54. 76 POP
 55. 77 STF
 56. 59 ILP
 57. 62 DCP
 58.  1 JMP  3
 59.  0 END  *
```

```
TRUCK
  1. 12 WID  7
  2. 15 RCL  3
  3. 26 CON  7
  4. 96 AND
  5. 14 STO  0
  6. 37 VUA
  7. 20 CDS  0,0
  8. 29 VUM  TRUCK
  9. 32 GSB  KEYS
 10. 33 NOP
 11. 26 CON  24
 12. 96 AND
 13.  2 JPZ  16
 14. 32 GSB  ERROR
 15.  1 JMP  9
 16. 15 RCL  3
 17. 26 CON  4
 18. 96 AND
 19.  3 JNZ  26
 20. 15 RCL  3
 21. 26 CON  2
 22. 80 SUB
 23.  3 JNZ  14
 24. 26 CON  -1
 25.  0 END  *
 26. 22 SNG  50,10
 27. 12 WID  12
 28. 20 CDS  8,0
 29. 15 RCL  3
 30. 26 CON  5
 31. 80 SUB
 32.  4 JPS  35
 33. 29 VUM  SPOT
 34.  1 JMP  37
 35.  3 JNZ  40
 36. 29 VUM  LOAD
 37. 26 CON  11
 38. 79 ADD
 39.  1 JMP  48
 40. 26 CON  1
 41. 80 SUB
 42.  3 JNZ  45
 43. 29 VUM  DUMP
 44.  1 JMP  46
 45. 29 VUM  QUE.
 46. 26 CON  12
 47. 79 ADD
 48. 14 STO  1
 49.  0 END  *
```

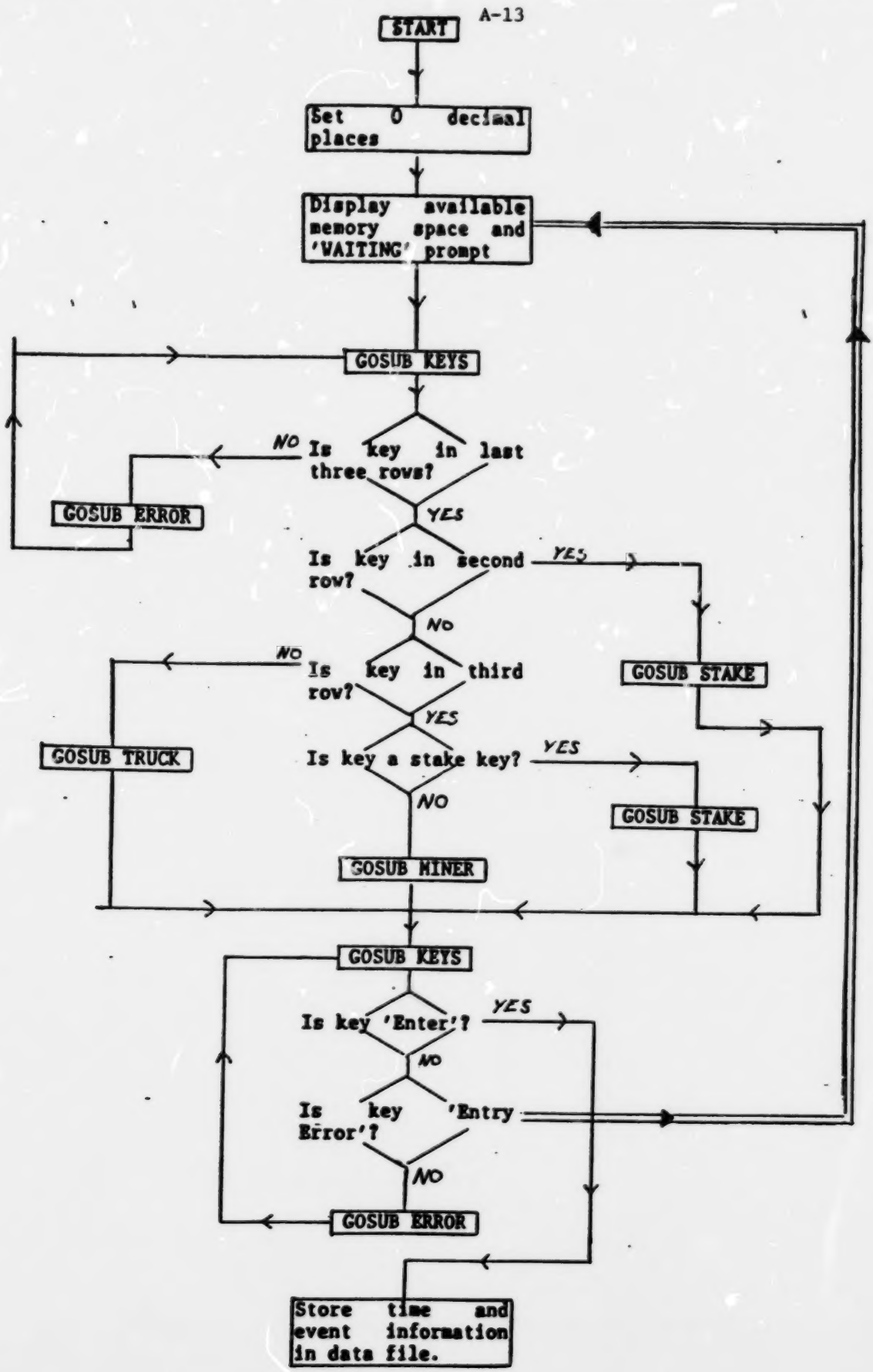
```
ERROR
  1. 22 SNG  60,5
  2. 11 DLY  1
  3. 22 SNG  60,5
  4. 11 DLY  1
  5. 22 SNG  60,5
  6.  0 END  *
```

```
STAKE
  1. 26 CON  8
  2. 14 STO  0
  3. 15 RCL  3
  4. 26 CON  6
  5. 96 AND
  6.  2 JPZ  11
  7. 15 RCL  3
  8. 26 CON  7
  9. 96 AND
 10.  1 JMP  22
 11. 15 RCL  3
 12. 26 CON  16
 13. 96 AND
 14.  2 JPZ  19
 15. 15 RCL  3
 16. 26 CON  8
 17. 80 SUB
 18.  1 JMP  22
 19. 15 RCL  3
 20. 26 CON  8
 21. 80 SUB
 22. 14 STO  1
 23. 12 WID  7
 24. 20 CDS  0,0
 25. 37 VUA
 26. 29 VUM  STAKE
 27.  0 END  *
```

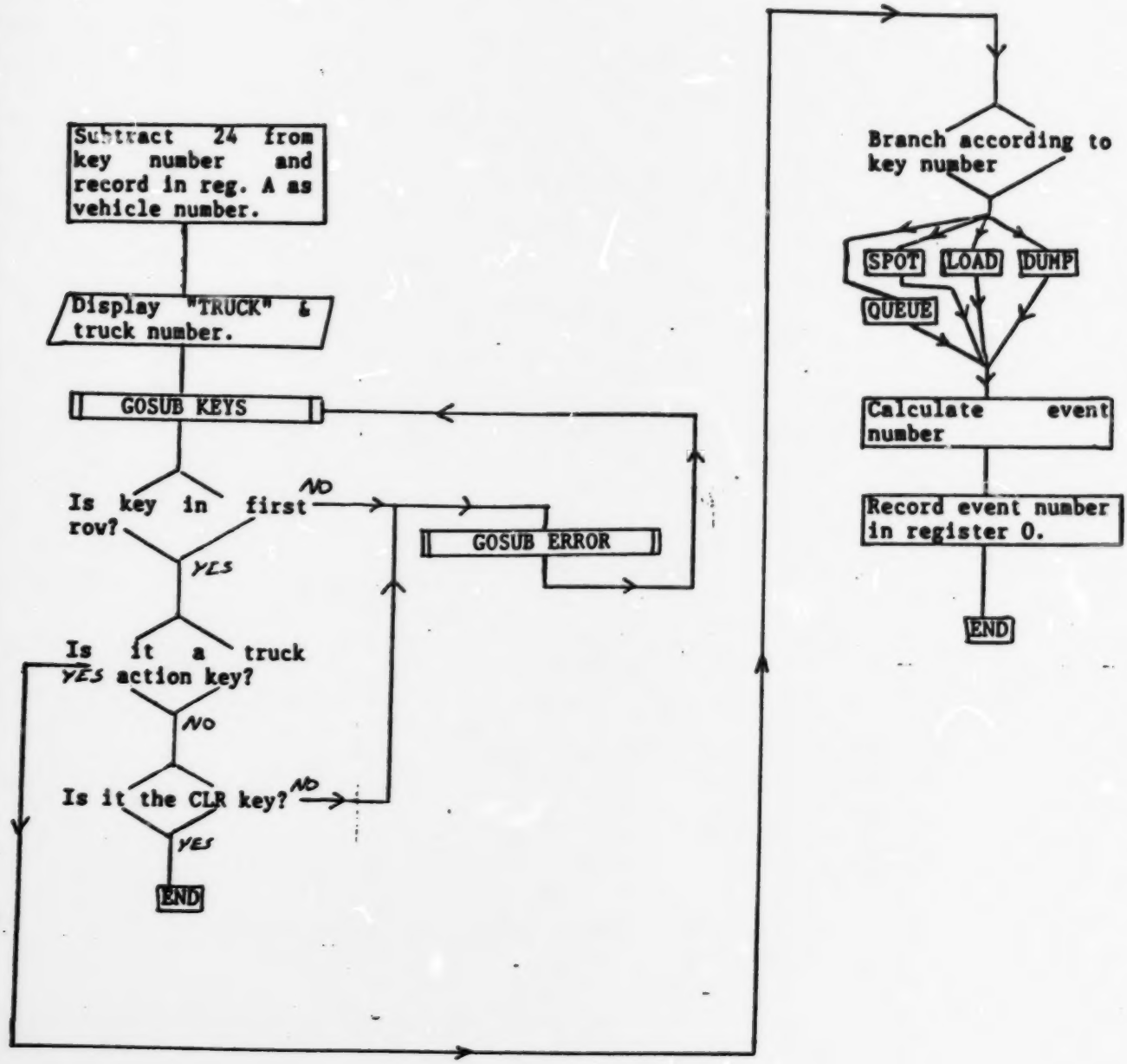
```
KEYS
  1. 51 IN9
  2.  3 JNZ  1
  3. 26 CON  255
  4. 50 INP
  5. 80 SUB
  6. 14 STO  3
  7.  0 END  *
  8.  0 END  *
```

```
START
  1. 31 OPN  EZMINE.E
  2. 93 LCT
  3. 76 POP
  4. 14 STO  0
  5. 26 CON  1
  6. 80 SUB
  7.  2 JPZ  17
  8. 26 CON  1
  9. 15 RCL  0
 10. 26 CON  1
 11. 58 SLC
 12. 78 RCF
 13.  3 JNZ  16
 14. 60 DLP
 15.  1 JMP  12
 16. 59 ILP
 17. 32 GSB  MAIN
 18.  0 END  *
```

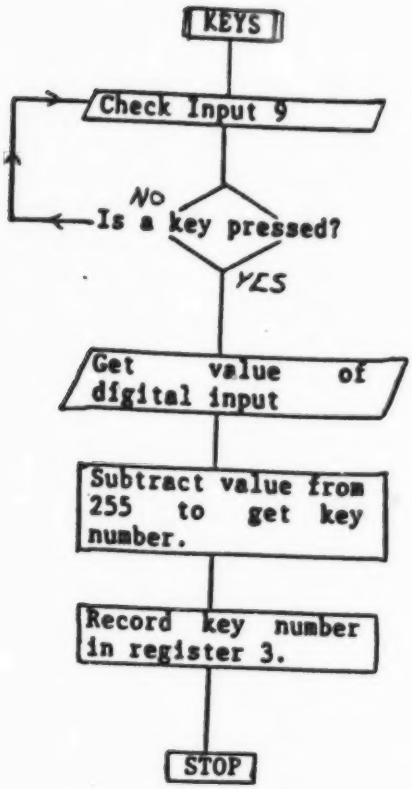
```
MINER
  1. 12 WID  11
  2. 26 CON  8
  3. 14 STO  0
  4. 15 RCL  3
  5. 26 CON  20
  6. 80 SUB
  7.  3 JNZ  10
  8. 29 VUM  MINER IDLE
  9.  1 JMP  24
 10.  6 JGZ  13
 11. 29 VUM  MINER DIG.
 12.  1 JMP  24
 13. 26 CON  2
 14. 96 AND
 15.  2 JPZ  22
 16. 29 VUM  ENTRY ERROR
 17. 26 CON  9
 18. 14 STO  0
 19. 26 CON  17
 20. 14 STO  1
 21.  0 END  *
 22. 29 VUM  MINER MOV.
 23. 26 CON  1
 24. 26 CON  15
 25. 79 ADD
 26. 14 STO  1
 27.  0 END  *
```



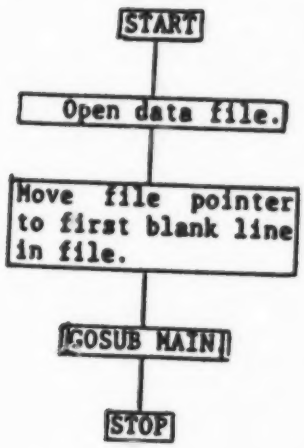
FLOWCHART FOR SUBROUTINE "MAIN"



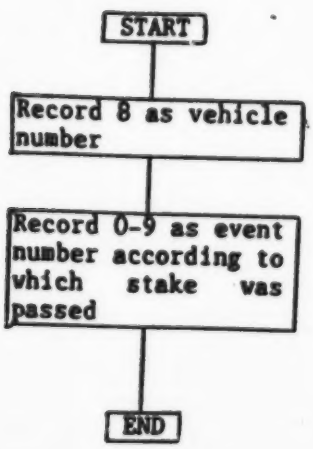
FLOWCHART FOR SUBROUTINE "TRUCK"



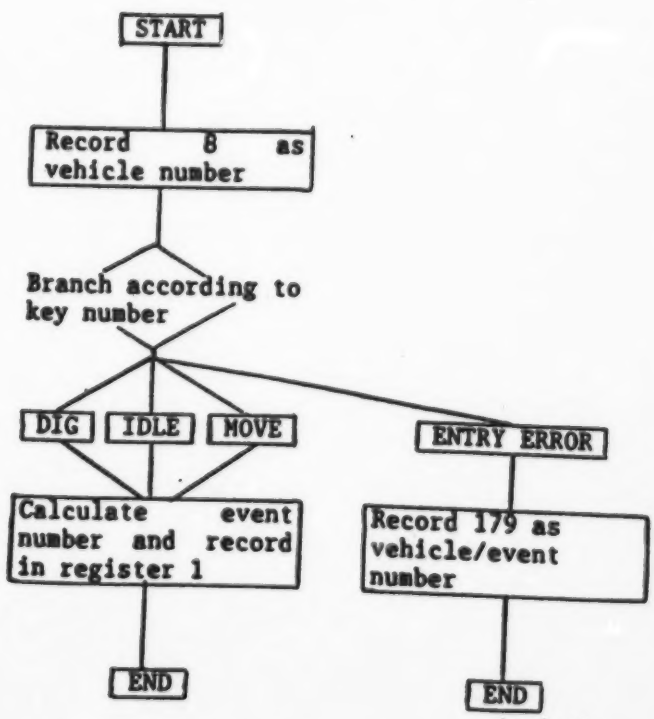
FLOWCHART FOR SUBROUTINE "KEYS"



FLOWCHART FOR SUBROUTINE "START"



FLOWCHART FOR SUBROUTINE "STAKE"



FLOWCHART FOR SUBROUTINE "MINER"

APPENDIX B

THE CROSSTALK FILES

APPENDIX B: THE CROSSTALK FILES

The transfer of files from the Polycorder to the IBM PC was automated using the facilities of the Crosstalk communications program. Crosstalk uses two kinds of files for operation: set-up files and communication scripts. The set-up files are chosen at the beginning of the Crosstalk session; the two relevant files are POLY1 and POLY2.

POLY1	POLY2	EXPLANATION
na Polycorder	na Polycorder (COM2)	set name to Polycorder
da 7	da 7	set seven bits per word
po 1	po 2	select COM port 1 or 2
go loc	go loc	set local mode

When a set-up file has been executed, the Crosstalk program looks for a script file with the same name. The script files used for this project are also called POLY1 and POLY2, and are identical.

```
ca +                    turn on capture buffer
when "&" jump done      wait for ampersand character to
wait manual             signal end of Polycorder data
label done              tone indicates that transfer is complete
a /                     set capture buffer to "pause"
wr                      save the capture buffer in a disk
ca -                    file and then clear it
```

Further information on the meaning of these programs can be found in the Crosstalk manual.